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# TANK TESTS OF A MODEL OF A FLYING-BOAT HULL WITH A FLUTED BOTTOM

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## SUMMARY

A 1/5-scale model of a flying-boat hull having flutes in the bottom both forward and aft of the step (N.A.C.A. tank model 19) was tested in the N.A.C.A. tank to determine its water performance. The model was also tested after the successive removal of the flutes on the afterbody and forebody. The results from these tests are compared with those from tests of a model of the hull of the Navy PN-8 flying boat and it is concluded that the fluted-bottom model and all its modifications are inferior to the model of the PN-8.

## INTRODUCTION

Longitudinally fluted bottoms have been used on a number of seaplane floats. The purpose, aside from possible structural considerations, seems to have been to reduce the high-speed resistance without greatly increasing the hump resistance. Prior to the present investigation tests were made at the N.A.C.A. tank on a model in which flutes were placed in the forebody only (reference 1). The effect of the flutes was found to be small, although they did cause some reduction in the high-speed resistance.

In the present tests a model of a fluted-bottom flying-boat hull was tested in the N.A.C.A. tank at the request of the Bureau of Aeronautics, Navy Department, for comparison with tests previously made in the tank on a model of the PN-8 flying-boat hull (reference 2).

## THE MODEL

The model was designed by the Navy as a 1/5-scale model of the hull of a hypothetical flying boat having the same load and get-away speed as the Navy PN-8. It has four longitudinal flutes on both the forebody and the afterbody, a broad second step, and a short tail. The model was made of laminated wood carefully smoothed and painted; for simplicity the sides were made vertical and a flat plywood deck was fitted. Figure 1 shows the principal lines of the model and the variations tested. The model numbers given to the variations are as follows:

| Model no. | Flutes on | Tail keel angle |
|---|---|---|
| 19 | Afterbody and forebody | 11°46' |
| 19-A | Afterbody and forebody | 15°30' |
| 19-B | Forebody | 15°30' |
| 19-C | None | 15°30' |

## APPARATUS AND PROCEDURE

All the tests were made by the hydrovane method as described in reference 1. Several alterations were made in the towing gear during the intervals between the tests of the model variations, and the last variation (19-C) was run with the towing gear as described in reference 3. The model was attached to the towing gear with the pivot about which the model trims at the position corresponding to the center of gravity of the complete flying boat. With the exception of 19-C all the variations of the model were balanced to give the correct longitudinal position of the center of gravity but were not balanced vertically. As the center of gravity of the model was lower than the position corresponding to that of the full-size flying boat, a small positive trimming moment was obtained in the free-to-trim condition. The towing gear used for model 19-C had provision for balancing the model vertically and it was accordingly balanced to bring the center of gravity both vertically and horizontally to the correct position at the pivot.

An initial load of 112 pounds (114,000 lb. full-scale) and a get-away speed of 39.4 f.p.s. (60 m.p.h. full-scale) were used for all tests. These values are the same as those used in the tests on a 1/5-scale model of the Navy PN-8 (reference 2).

## TEST PROGRAM

The model as originally made (19) was tested free to trim and at 10°, 8°, and 6° fixed trims, over the useful range of each, as requested by the Navy. The tail was then raised and the effect of this change on the hump resistance and the trim angle was determined by running the model (19-A) free to trim. The flutes were then removed from the afterbody and the model (19-B) tested under the same trim conditions as the original model (19). The last test was made with all flutes removed from the model (19-C).

## RESULTS AND DISCUSSION

Curves of resistance, rise, trim angle, trimming moment,* and load/resistance ($\Delta/R$) are plotted in figures 2 to 5. As an aid to comparisons, the upper envelopes of the $\Delta/R$ curves for models 19, 19-B, 19-C, and 9 (PN-8) are plotted in figure 6. The curve for the PN-8 model is taken from figute 5 of reference 2

For all the variations tested the resistance curve for 8° fixed trim falls very sharply at about 30 f.p.s. This condition occurs when the model is riding on the second step and, since the negative trimming moments are so large that this condition has no practical application, the 8° fixed trim during this condition was neglected in deriving the envelopes of the $\Delta/R$ curves.

Model 19 has a slightly better $\Delta/R$ value than the PN-8 at the hump. This slight gain is partly offset, however, by the higher speed at which the hump occurs. At all speeds beyond the hump, the $\Delta/R$ values for model 19 are considerably lower than those for the PN-8.

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*Positive moments tend to raise the bow.

Raising the tail, of course, allowed model 19-A to take slightly different trim angles and the differences in the free-to-trim resistance curves of models 19 and 19-A may be at least partly attributed to this change in trim angles.

Model 19-B, with flutes on the forebody only, gave a $\Delta/R$ curve that lies between the curves for model 19 and the PN-8. Over most of the high-speed range, the $\Delta/R$ values for model 19-B are a little lower than the $\Delta/R$ values of model 19.

Model 19-C (no flutes) was the best at the hump and the worst at high speeds. Its $\Delta/R$ value at the hump is well above that of the PN-8, but at high speeds the $\Delta/R$ curve is much lower.

Model 19 threw less spray than the PN-8. The removal of the flutes in models 19-B and 19-C caused a slight increase in the spray but the increase was not enough to make either as bad as the PN-8.

## CONCLUDING REMARKS

Since these tests were made at widely separated intervals over a period of 18 months, during which the equipment of the tank was altered considerably by changing the towing gear and the method of suspending and balancing the model, definite quantitative comparisons showing the effect of the flutes are impracticable. Furthermore, the effect of raising the tail was not fully determined because only free-to-trim tests were run on model 19-A. It does seem permissible, however, to conclude that the flutes on the forebody and/or the afterbody will have little effect on the take-off performance.

The increase in the keel angle of the tail seems to have been unnecessary for at high speeds where a low keel angle might give trouble the tail in its original form was well out of the water

Near get-away it is probable that the trim angle giving least resistance is less than 6°, the lowest fixed trim tested.

As a definite conclusion the results indicate that this design, with or without the flutes, will give poorer take-off performance than the PN-8.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., February 20, 1935.

## REFERENCES

1. Truscott, Starr: The N.A.C.A. Tank - A High-Speed Towing Basin for Testing Models of Seaplane Floats. T.R. No. 470, N.A.C.A., 1933.

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3. Shoemaker, James M.: Tank Tests of Flat and V-Bottom Planing Plates. T.N. No. 509, N.A.C.A., 1934.

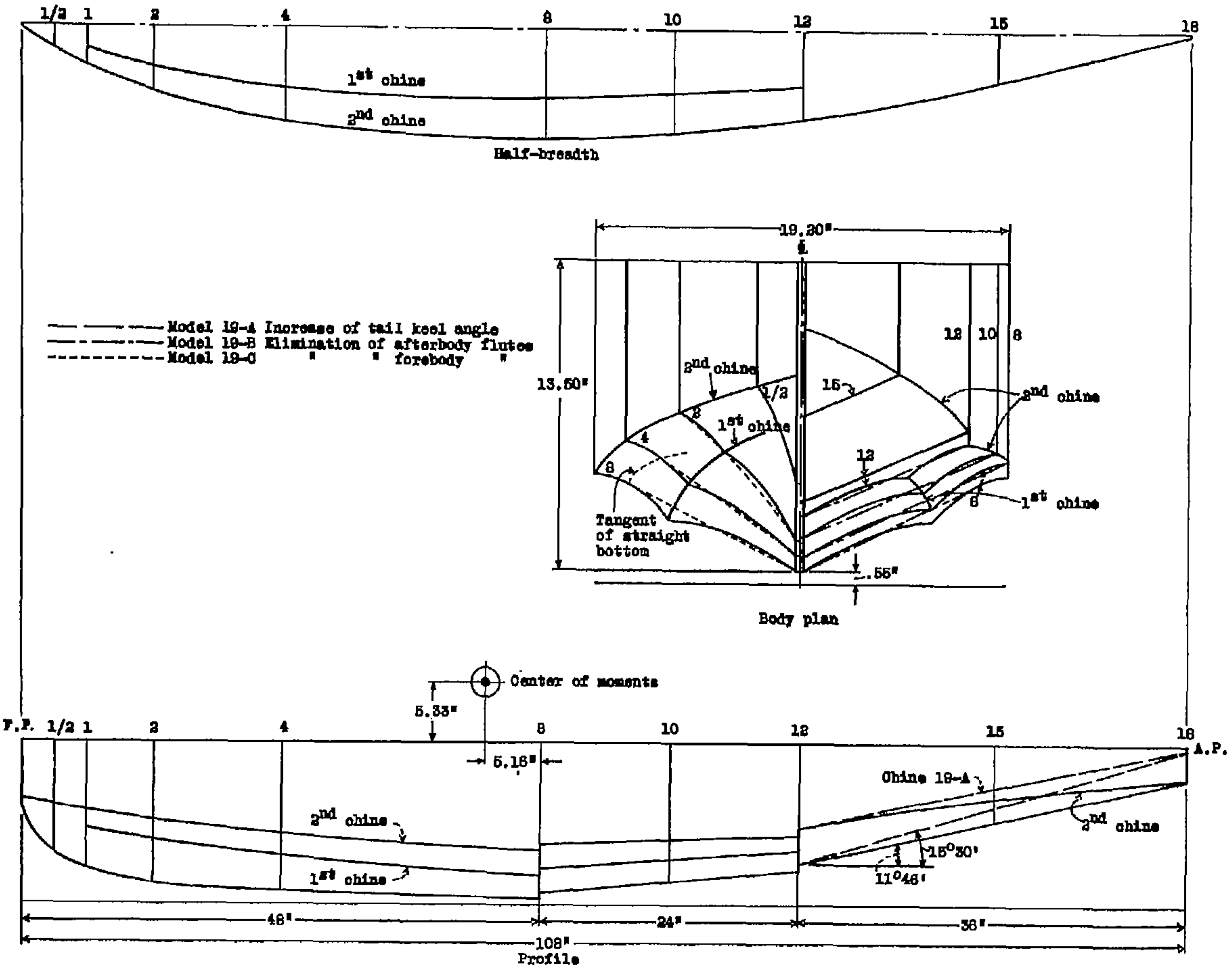


Figure 1.-Lines and alterations of Model 19.

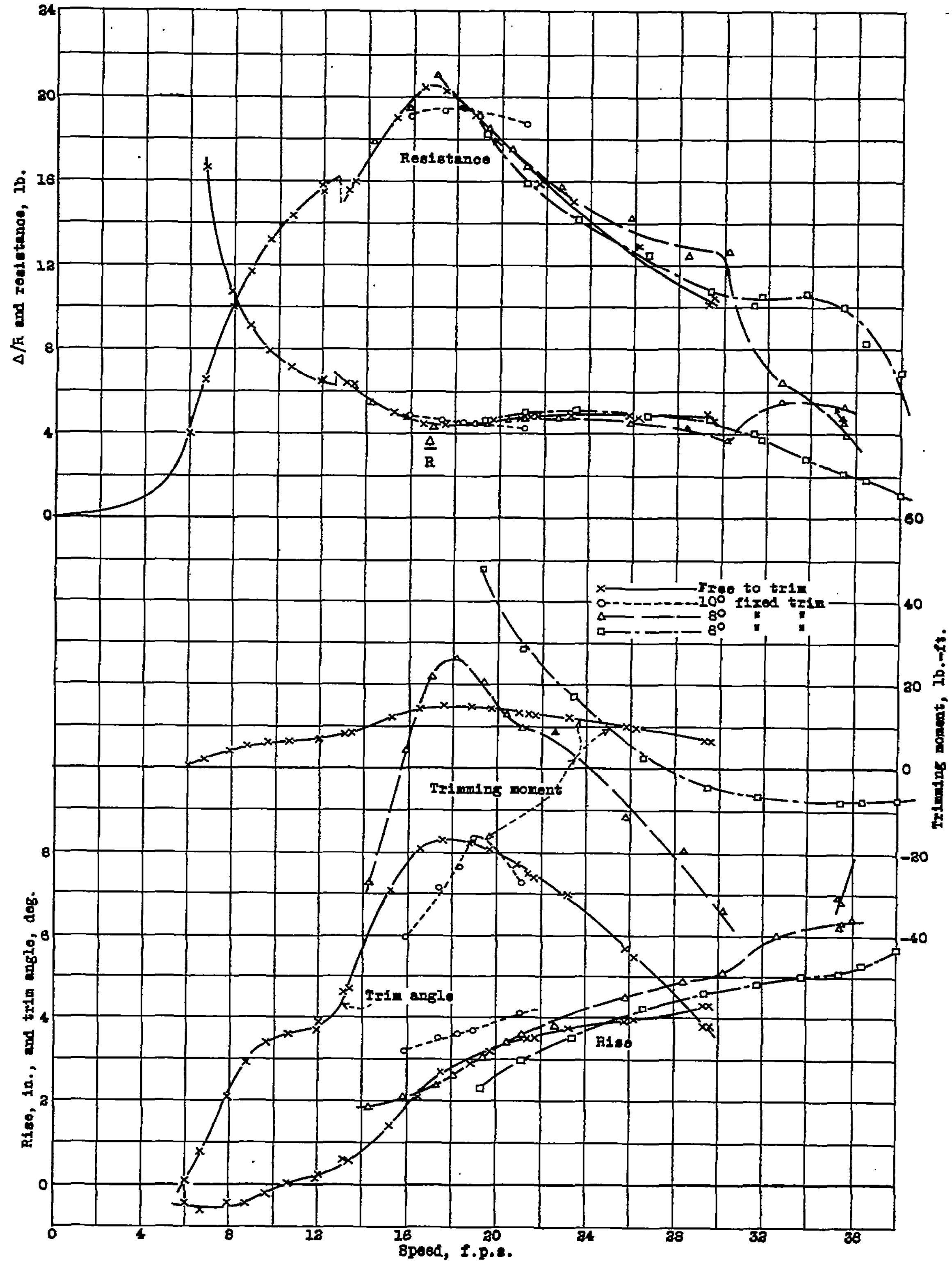


Figure 2.-Water characteristics of Model 19. Flutes on forebody and afterbody, tail keel angle, 11°48'; initial load, 112 lb.; get-away speed, 39.4 f.p.s.

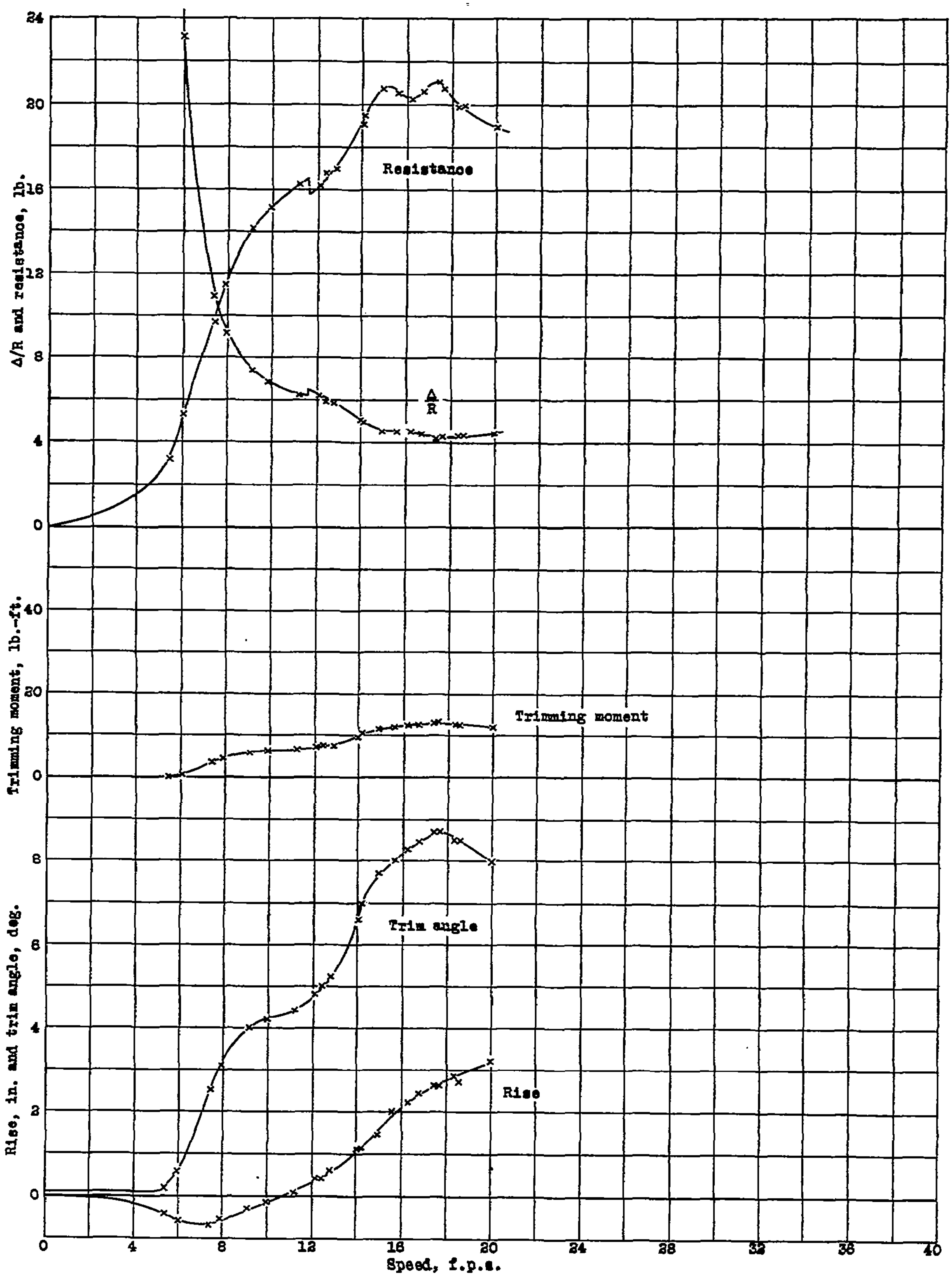


Figure 3.- Water characteristics of Model 18-A, free to trim. Flutes on forebody and afterbody; tail keel angle, 15° 30'; initial load, 112 lb.; get-away speed, 39.4 f.p.s.

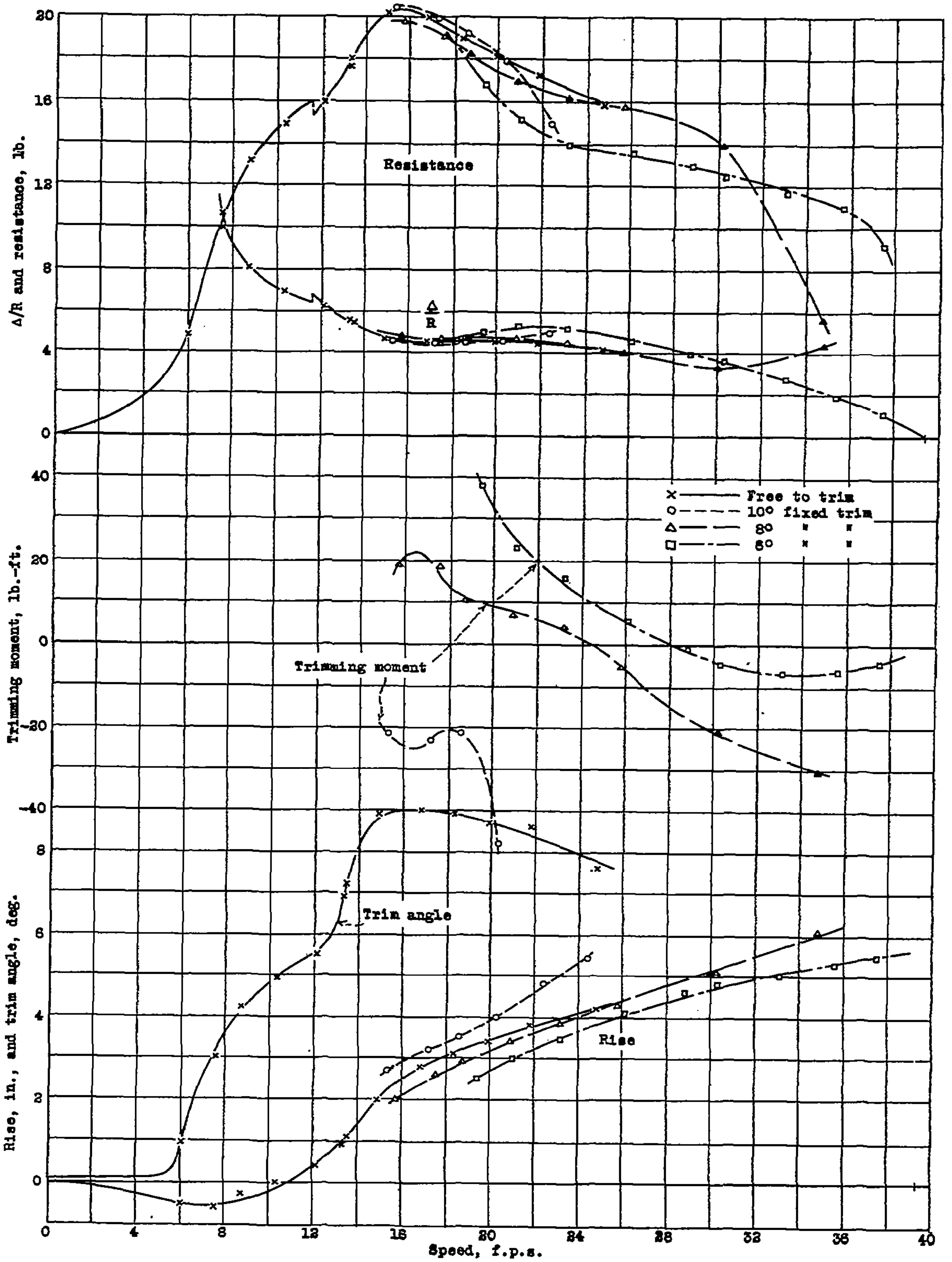


Figure 4.- Water characteristics of Model 19-C. No flutes; tail keel angle, 15° 30'; initial load, 112 lb.; get-away speed, 39.4 f.p.s.

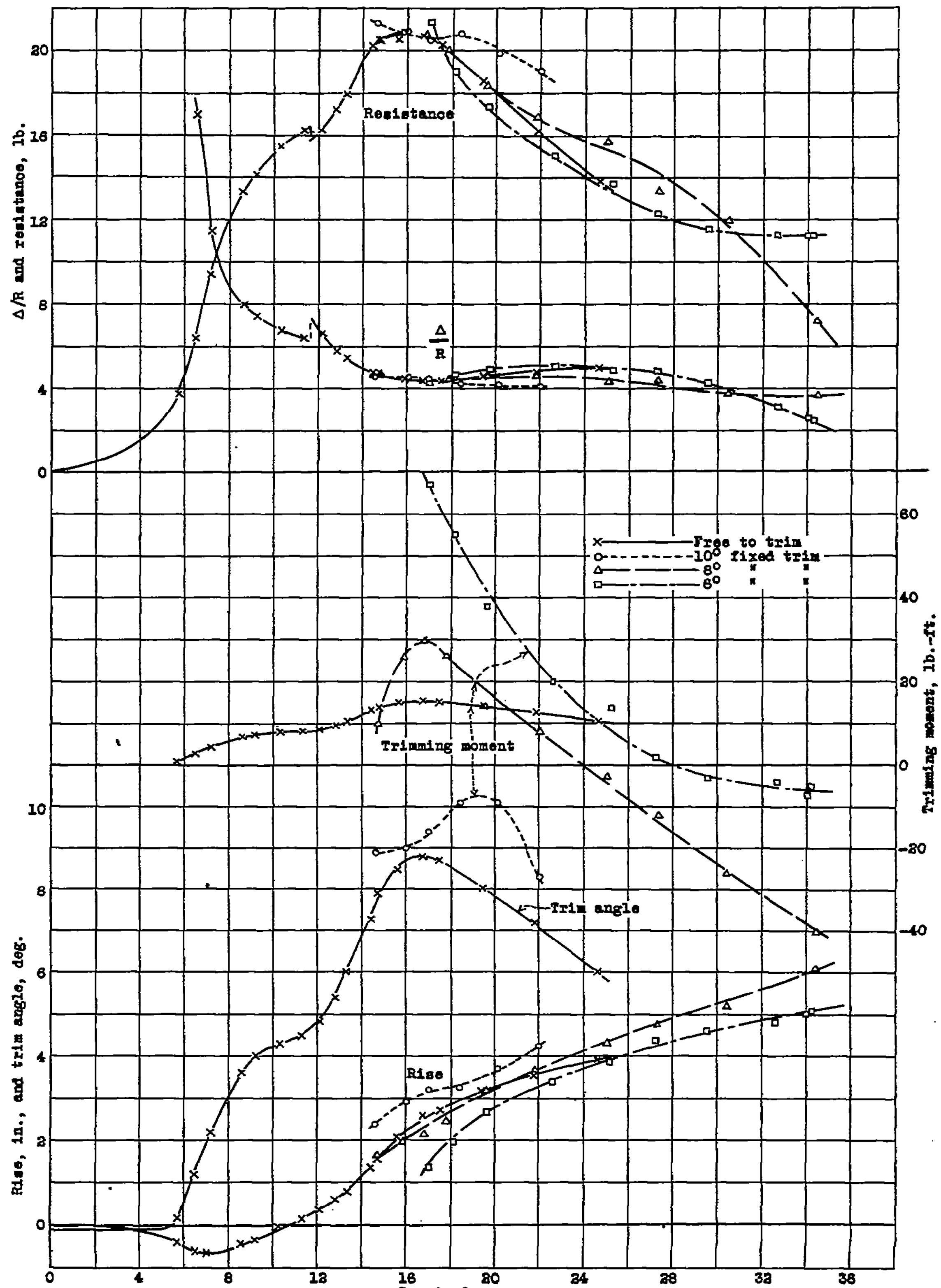


Figure 5.-Water characteristics of Model 19-B. Flutes on forebody only; tail keel angle, 15°30'; initial load, 112 lb.; get-away speed, 39.4 f.p.s.

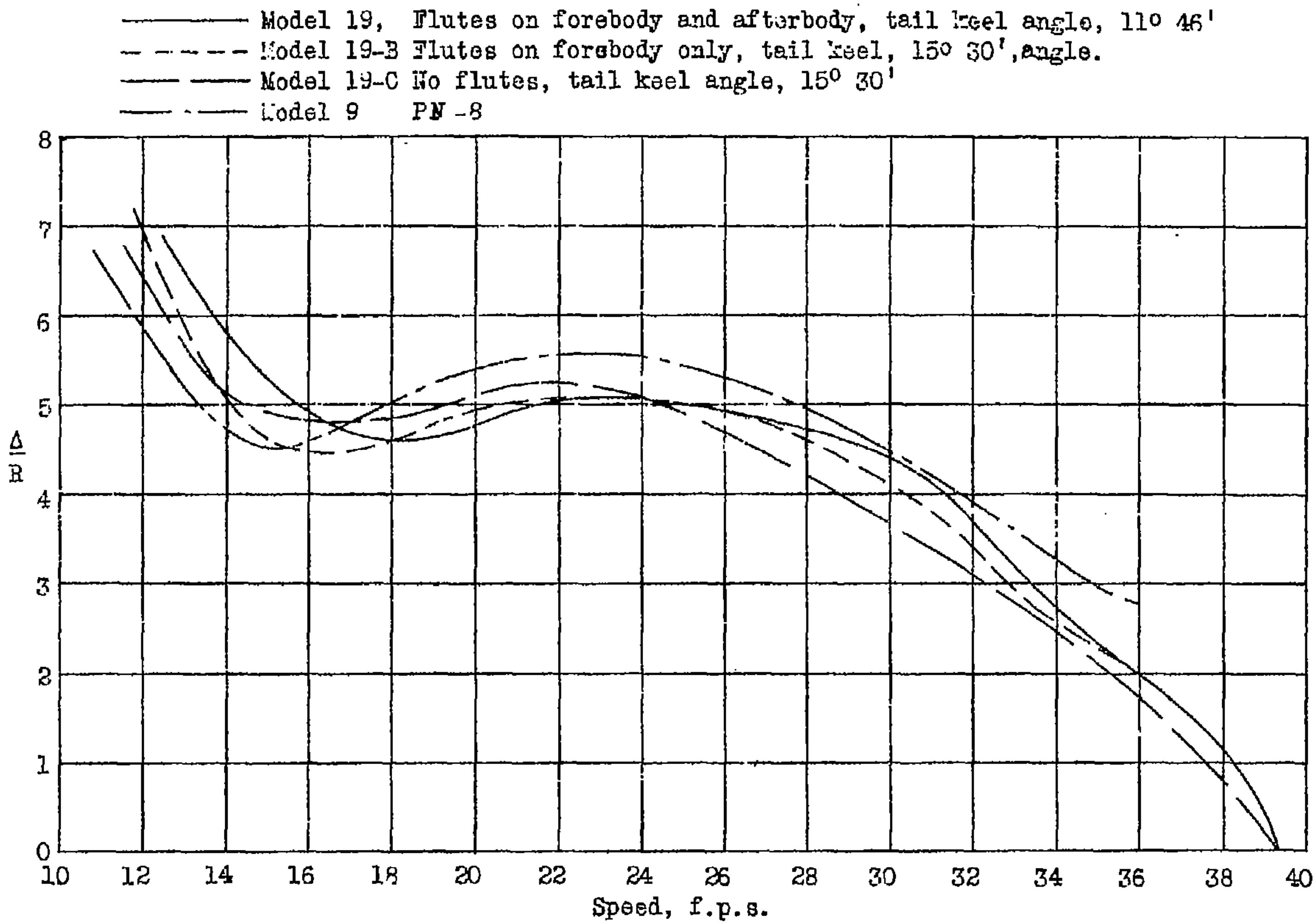


Figure 6.- Effect of flutes on Δ/R